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UNITED STATES DEPARTMENT OF AGRICULTURE

FOREST SERVICE

HEBGEN LAKE •• MADISON RIVER EARTHQUAKE DISASTER

AUGUST 1959

GALLATIN-BEAVERHEAD •• NATIONAL FORESTS



REGION ONE

Chas. L. Tebbe Regional Forester

MISSOULA MONTANA

**United States
Department of
Agriculture**



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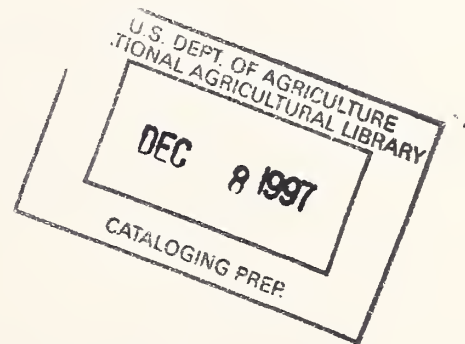
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PART I. INTRODUCTION

At approximately 11:35 p.m. on August 17, 1959, a severe earthquake centered in western Montana rocked a five-state area. The greatest local force of the quake apparently centered in the Hebgen Lake-Madison River area within the Gallatin and Beaverhead National Forests. Geologists state this to be the fourth most severe quake recorded in the United States.

Early reports from the area were sketchy because communication facilities were disrupted and roads blocked. Information relayed from the area was based on observations that the water in the Madison arm of Hebgen Lake suddenly receded. This led to a logical but unfounded conclusion that the Hebgen Lake dam had failed.

A series of tidal waves generated by the earthquake in the Hebgen Lake Reservoir caused the dam to be overtopped at least three times and caused some flooding of the canyon below. The immense slide at the mouth of the canyon prevented people from evacuating the area and blocked rescue efforts. Part of the highway between West Yellowstone and the dam was closed due to slides, slip outs, and crevices. This blocked the only other means of ingress and egress to the Hebgen Lake-Madison River canyon area.

It was known that many people were camped in the canyon below Hebgen Dam. This stretch of the Madison River is one of the most popular fishing and camping areas in Montana. With the lack of communications, the darkness, and access to the area blocked by slides it was impossible to appraise the situation immediately. Initial rescue efforts were limited to campers helping each other.

It was under these conditions that the Forest Service and Federal, State, county, and other agencies first entered the picture to determine the actual conditions and to render assistance in every way possible.

PART II. SEARCH AND RESCUE OPERATIONS

A. SUMMARY OF ACTION - WEST YELLOWSTONE-HEBGEN LAKE-MADISON CANYON SECTOR

1. August 18, 1:30 a.m. to 8:00 p.m. First word of the disaster reached State Civilian Defense Director Hugh Potter at Helena at 1:30 a.m. on August 18. The message was transmitted through the OCDM national warning system. Reports of the disaster in the Hebgen Lake area were relayed by "ham" radio operators at West Yellowstone. The earliest reports stated the dam had failed. Conflicting "yes" and "no" reports on the dam were received by OCD until 4:30 a.m. At that time Gallatin County Sheriff Don Skerrits informed Director Hugh Potter that the dam was holding.

Director Potter took action, based upon this first positive report at 4:30 a.m., to alert State agencies of the emergency situation. Action was taken immediately by the Montana Highway Department, State Highway Patrol, Montana Aeronautics Commission, Montana Fish & Game Department, the Governor's office, and other State units to accomplish their respective missions in disaster mobilization and relief.

During this period, the 4th Air Force Headquarters at Hamilton Air Force Base, California, hearing the national warning system disaster message, placed all of their search and rescue resources at the disposal of Montana's governor and State civilian defense director. Within a short time rescue squadrons and support groups, with fixed wing and helicopter aircraft, fully manned and equipped, were moving to West Yellowstone from:

41st Air Rescue Squadron, Hamilton Air Force Base,
California
2849th Air Base Wing Rescue, Hill Air Force Base, Utah
3638th Flying Training Squadron, Stead Air Force Base,
Nevada
4061st Support Group, Malmstrom Air Force Base, Montana

Montana Aeronautics Commission personnel, operating under the Civilian Defense Mobilization Plan, were dispatched to West Yellowstone to direct air traffic control and related services at West Yellowstone airport.

Other Federal agencies and western state governors volunteered all-out assistance. Canadian Government organizations offered their services. Idaho State Civilian Defense, Idaho State Police, and Idaho State Highway Department personnel immediately started action to move their forces into West Yellowstone to assist with evacuation and disaster relief.

Montana Power Company representatives mobilized their organization to assist with examinations and emergency repairs at Hebgen Dam and communications from that vital point. Montana Power Company requested and immediately received assistance from the State Highway Department, the Bureau of Public Roads, and highway contractors Naranche and Konda who had considerable equipment on the Gallatin River Highway construction job.

Representatives of Federal, State, and county agencies near and within the disaster area swung into action in meeting demands of the emergency situation. Johnson Flying Service, Missoula, responded immediately to a request from Director Potter for dispatch of a helicopter to the Gallatin Canyon slide area. Gallatin and Madison County sheriff's office personnel and doctors and nurses in the West Yellowstone and Ennis areas responded promptly by going to the distressed areas, administering first aid and caring for the injured. (Refer to Appendix 3 - List of Cooperating Organizations.)

Concurrently with these outside actions, people nearby or trapped by the large landslide at the mouth of the canyon (and the State Highway destruction along Hebgen Lake) were assisting with first aid and rescue work. Approximately 250 persons were trapped in this general area. Those injured received care and first aid. Bodies were removed. People near the slide were moved to high ground out of the path of rapidly rising water forming a lake behind the slide.

Early morning telephone communications between Supervisor Fry, Dillon, Montana, Assistant Regional Forester H. O. Robe who was at the Wise River Ranger Station on the Beaverhead National Forest, and Regional Forester C. L. Tebbe served to define the action needed. Regional Forester Tebbe then arranged for dispatch of Forest Service men and equipment into the area.

Forest Service smokejumpers from Missoula, in charge of A. C. Hammond, hit the ground in Madison Canyon (between Beaver Creek and the slide) at about 10:30 a.m. This skilled rescue and first aid team, radio equipped, aided the injured, prepared helispots, and assisted with evacuation operations.

Robe was assigned overall responsibility for directing Forest Service action and coordinating it with assisting departments and agencies. He proceeded first to Ennis and, after establishing a suitable organization at that point, went on to West Yellowstone where he directed the organization of Forest Service rescue efforts, and coordinated the work of cooperating departments and agencies.

Robe undertook to assess the situation and clarify the overall job needed to be done. There were many people and agencies helping and wanting to help in the ways they could. It was an easy matter to parcel such work out among willing people and agencies, but it was essential that someone assume responsibility for marshaling the forces available, maintaining a central headquarters, and correlating agency actions and information. This, Robe did throughout the first days of the operation, with assistance of staff organization and key Service units, headed by:

Ennis Sector

E. J. Grambo, C. B. Sutliff, R. E. Frey, C. B. Westcott, W. E. Steuerwald, J. F. Hamblet, H. P. Gauld, A. A. Johnson, F. O. Brauer, Forest Supervisor W. E. Fry, F. T. Bailey, B. C. Reeves, D. W. Nelson, Rangers Neil Howarth, Chet Hagedorn, Blaine Tennis, John Venrick, and Robert Gibson

West Yellowstone Sector

J. R. Milodragovich, Ed Barry, F. J. Heinrich, Arval Anderson, Max Peterson, Forest Supervisor George Duvendack, D. W. Beaman, H. F. Johnson, Rangers Craig Silvernale, and G. P. Wetzsteon

Forest Service personnel, who by the very nature of their normal duties, are well equipped and trained to meet emergency situations, rose to the occasion. Moving as a unit, they worked long hours - many of them worked around the clock - in facilitating search and rescue operations, aiding distressed people, and working with representatives of cooperating organizations. Refer to Appendix 5 for the list of the 104 Forest Service personnel who participated in search, rescue, and supporting missions.

Air Force and Johnson Flying Service helicopters evacuated injured persons from the slide area to Ennis Hospital and West Yellowstone. From the latter, airport stretcher cases were flown by Air Force and Johnson planes to the Bozeman Hospital. Bodies were transported to Ennis and West Yellowstone by car, ambulance, and helicopter.

The American Red Cross, State and local civic organizations, Salvation Army, and private individuals did an outstanding job in providing care and assistance to the evacuees. The Red Cross established temporary bases at West Yellowstone, Ennis, and Virginia City. Inquiries were handled by the Gallatin County Red Cross Chapter at Bozeman, Montana, where over 2,800 inquiries were processed up to August 25. The Idaho Civil Defense Unit, headed by Lewis Ross, and the Red Cross, headed by R. M. Wiseman, set up a relief station at West Yellowstone Airport which provided much helpful service to evacuees.

Officials of Montana State College, Bozeman, made arrangements to house and feed 180 evacuees in one of the dormitories. Mr. and Mrs. Wells, owners of the Kirkwood Guest Ranch, fed and cared for 50 to 60 people in addition to their 45 regular guests until roads were opened and means provided for evacuation. At Ennis, high school board members opened the high school gym and cafeteria to shelter and feed evacuees and workers. There were many other acts and deeds of human kindness.

On August 18, the Bozeman Sheriff's Posse, with pack outfit, reported for search and rescue duty. They were assigned an area including Wapiti Creek and Beaver Creek, and given instructions to search for parties that may have been in the area at the time of the earthquake. The route of travel was up Wapiti Creek over into the head of Beaver Creek and downstream to Beaver Creek cabin. They were given a message for the road crew to remain at Beaver Creek cabin until relieved or withdrawn. The mission was completed in good time and no casualties were found.

The Forest Service dispatcher at West Yellowstone Ranger Station contacted the county sheriff at 6:00 a.m., August 18, and briefly discussed plans for coordinated effort and assistance. Difficulty was encountered in securing reliable information from outside sources as both Forest Service and commercial telephone communications failed.

When the seriousness of the situation was realized at about 7:30 a.m., Ranger Craig Silvernale held an organizational meeting and placed all district employees on the alert. Two district crews, with tools and equipment, were dispatched to survey damages, render assistance, and open roads in the 120-unit summer home area on the west side of Hebgen Lake.

About 7:00 p.m. dozers, directed by Montana Highway Department personnel, completed a "shoo-fly" road connecting Duck Creek Y, Hebgen Dam, and Beaver Creek (in Madison Canyon). By about 9:30 p.m., all people (who wished to go out) and most cars were evacuated from the disaster area between the slide and Hebgen Dam. State Highway Patrol officers were instrumental in moving cars over the rough dozer road sections without accident.

At 8:00 p.m., the Forest Service called a meeting of all agency representatives, held at the West Yellowstone Ranger Station. (Refer to Appendix 4 for list of agency representatives.) Information concerning the general situation was pooled. Action plans for each agency and organization for the following day, August 19, were agreed upon. Objectives and major effort in various areas were decided, with the Forest Service coordinating overall on-the-ground action.

2. August 19. The action plan developed in the coordination meeting held at 8:00 p.m. on August 18 for the Hebgen Lake-Madison Canyon slide area was activated under direction of Forest Service Civilian Defense Coordinator John Milodragovich, Missoula, after a 5:00 a.m. breakfast, as follows:

a. Search and rescue - ground scouting in Madison Canyon

- (1) Mission - scour river and canyon area from dam to slide for bodies, cars, trailers, etc. Make contact with Ennis crews working up from below slide.
- (2) U. S. Forest Service employees Bill Beaman and Ole Johnson, with Gallatin Forest radio - Al Hammond and smokejumpers. Bozeman Sheriff's Posse assisted.

b. Air search and rescue

- (1) Mission - scour river and canyon plus all high-country areas in Gallatin Forest. Area zoned into four sectors by Forest Supervisor Duvendack. Systematic aerial coverage with emphasis on searching for fishermen, recreationists, dude outfits, pack trains, and others possibly injured or trapped by slides or rolling rocks in high-country lakes and wilderness area.
- (2) Unit headed by Supervisor Duvendack and Ranger Silvernale.
- (3) Air support - Major G. H. Carlton, Montana State College AFROTC Coordinator.
 - (a) Four Air Force helicopters - Captain A. S. Champion, Mission Commander.
 - (b) Johnson Company helicopters - Pilots Swede Nelson and Rod Snyder.
 - (c) State Fish & Game Department plane - Joe Townsend and Pilot Jim Stradley.
 - (d) Col. G. B. Bennett and Idaho National Guard unit to stand by for support or emergency search and rescue action.
- (4) OCD air traffic control unit was very effectively operated by Charles Lynch and Mark Radcliffe of Montana Aeronautics Commission at West Yellowstone Airport. They assured safety and coordination of aircraft departures and arrivals and policed unauthorized private plane traffic.

c. Road blocks - traffic control - looting prevention

- (1) Mission - establish road blocks at Duck Creek Y and South Fork Madison-Watkins Creek roads. Keep all unauthorized persons out of area. Admit press, radio, TV, and property owners with credentials.
- (2) Alex Stephenson, Chief, Montana State Highway Patrol, assisted by Captain Ben Neuman, Idaho State Police.

d. Ground patrol - west side Hebgen Lake

- (1) Mission - check summer home areas and roads to end of known habitation area. Assist with further evacuation. Urge 75 people in area to clear out because of hazards.
- (2) Group leader Ed Barry, Assistant Regional Forester, Forest Service, Missoula, assisted by Cliff Amundsen, Bureau of Land Management and crew, radio equipped.
- (3) In p.m. crew assisted a number of people out of Rainbow Point area by opening up road.

e. Boats with outboards standing by for search and rescue on Hebgen Lake. Dangerous because of drift. Not used today.

f. Forest Service established engineering office. Information and services were provided by Regional Engineer Arval Anderson and Assistant Max Peterson. Business was good in assisting Corps of Engineers, Montana Power Company, BPR, USGS, Bureau of Reclamation and other groups.

g. Additional organization action

(1) Arrivals

Harold Tepper, Deputy Director of OCDM, Everett, Washington
Frank H. Chick, Staff Engineer of OCDM, Everett, Washington.

Made aerial reconnaissance of disaster area.
Rendered valuable assistance and advice to Forest Service coordinator and various agency representatives.

Gareth C. Moon, State Forester, and Deputy Director,
State Civil Defense.

Made aerial reconnaissance of area. Briefed by
Forest Service coordinator and staff preliminary
to assumption of Civilian Defense direction and
coordination of all activities.

8:00 p.m. - coordination meeting held. Attended by
agency representatives. Action plan for following
day developed.

h. News releases and press contacts

John Milodragovich correlated information from all sources
for press, radio, and TV service.

3. August 20. Activated plans developed at previous evening
meeting.

a. Air search

Mission - re-cover entire Madison Canyon and high country.
Scour area for people in trouble.

Damage survey carried on as secondary mission. Damage
to roads, trails, campgrounds, other improvements
appraised and mapped.

Same personnel and aircraft as on August 19 plus Ole
Johnson and Assistant Ranger Gary Wetzsteon.

b. Ground search - Madison Canyon

Bill Beaman, U. S. Forest Service, and crew. Scoured can-
yon area. Assisted with removal of house trailers to loca-
tions safe from being inundated by rapidly rising
Earthquake Lake. Bozeman Sheriff's Posse assisted.

c. Road blocks

Maintained in same locations as August 19 by Montana
Highway Patrol.

d. Plans laid for intensive damage appraisal by Regional
Engineer Anderson and Max Peterson, U. S. Forest Service.

e. Cooperation with Corps of Army Engineers, U. S. Geological
Survey, Bureau of Reclamation, and representatives of
other agencies.

- f. Major Sumner Gerard, Civil Air Patrol, arrived with staff at 9:55 a.m. Installed radio equipment at Hebgen Dam and West Yellowstone headquarters. Gerard directed similar action in installation of CAP radio equipment at Ennis and a relay station on the Gravelly Divide, Beaverhead National Forest.
- g. Skindivers affiliated with the Livingston and Bozeman rescue units worked tirelessly in their search for bodies in the Lower Hebgen Lake in the vicinity of Kirkwood Creek and in the backwater above the slide area. There had been reports that a car loaded with people had fallen in the lake when the road caved in. They also carefully searched a house which had slid into the lake. No bodies were found as a result of the skindivers' efforts.
- h. Civilian Defense Director Hugh Potter and Deputy Gareth Moon held a coordination-demobilization meeting at 1:30 p.m. with agency representatives. A second meeting was held at 8:30 p.m. with the following responsibilities agreed upon for future action:

- Overall coordinator - Hugh Potter
- Communications - Civil Defense
- Policing - sheriffs (Highway Patrol)
- Rehabilitation work and death records and inquiries - Red Cross
- Body search and recovery - sheriffs
- Property salvage (cars, trailers, etc.) - sheriffs
- Search and damage surveys - Forest Service
- National forest development roads - Forest Service
- State roads - State
- County roads - County
- Hebgen Dam damage - Montana Power Company

- 4. August 21. Director Hugh Potter, designated as coordinator by Governor Aronson, activated the plans agreed upon at the coordination meeting held the previous evening with representatives of cooperating agencies. Action was taken to set up radio communication with Civil Defense sets, between Hebgen Dam and Ennis. The CAP radio installations and facilities were withdrawn. Body search, rescue, property salvage, and protection responsibilities were specifically assigned to the county sheriffs. The State Highway Patrol continued to handle traffic control. Red Cross activities were continued under the direction of Mr. Wiseman. Aerial search and damage surveys were continued by the Forest Service under the direction of Anderson and Peterson. Aerial photographs were taken of the disaster area.

Forest Service personnel assigned to such emergency-type activities as first aid treatment, radio installation, and evacuation were demobilized and returned to their regular stations. Coordinating Forest Service personnel with special assignments remained and assisted Civil Defense Coordinator Hugh Potter.

General Barney, Division Chief, Army Engineers, Omaha, Nebraska, arrived at West Yellowstone after making a field trip of the disaster area. General Barney and his associates conferred with Forest Service Engineers Anderson and Peterson.

At 9:00 p.m., a conference was held by Governor Aronson and Director Hugh Potter with key cooperating personnel for the purpose of making preliminary plans for presenting to the Congressional delegation the events and the action taken to solve the problems resulting from the earthquake. Plans for helicopter trips over the disaster area were made. Arrangements were also made to have forest maps, aerial photographs, and other informational material available for the members of the Congressional delegation.

The Ennis operation base was demobilized of Forest Service personnel, with the exception of resident forest officers of the Beaverhead National Forest engaged in damage survey.

5. August 22

- a. A party of Army Corps of Engineers started work on the slide.
- b. The Congressional delegation arrived and flew the heavy damage area in Army and Johnson Flying Service helicopters.
- c. Reports, maps, photographs, and outlines were prepared by the Forest Service for information of the Congressional party.
- d. Charts and aerial photo maps were prepared for the evening meeting.
- e. The delegation was briefed on the action taken and on contemplated action. Preliminary damage estimates were given them.
- f. Transportation to return the delegation to Bozeman was arranged with the Highway Patrol.
- g. Fred Brauer worked to tighten up the flight restrictions over area that were requested on August 18.

6. August 23

- a. Congressional delegates left by car for Bozeman.
- b. Clint Davis, U. S. Forest Service, Washington office, flew area in helicopter and was flown to Billings by Dillon patrol plane.
- c. U. S. Air Force helicopters and transports were released from their mission.
- d. Eleven regional office personnel transported to Missoula by plane.
- e. All freight for Missoula Fire Warehouse picked up.
- f. All motels checked for property or obligations.
- g. Stenographers started typing for Army Corps of Engineers.

7. August 24

- a. Witness statements obtained from personnel and residents of the disaster area.
- b. Typing for Army Corps of Engineers.
- c. Stencils flown to Belgrade so contracts could be produced.
- d. Helicopter agreement developed with Army Engineers on J Ranger.
- e. Helicopter flights made for survey of damage to roads, trails, and fish and wildlife habitat.
- f. Airport management controversy arose over charges for use of field.
- g. Action taken by Forest Service to establish a 24-hour radio warning net from Hebgen Dam to Ennis. Essential to insure positive communication for evacuation of Ennis and Madison River lowlands residents in event of another quake and possible failure of Hebgen Dam.

8. August 25

- a. Transferred J Ranger helicopter to Army Engineers.
- b. Meeting held with airport manager and airport board member from Gallatin County.
- c. F.A.A. Safety Officer Hendee flew over slide area to enforce 9,000-foot ceiling.
- d. Arranged transportation to Missoula for eight Forest Service personnel.
- e. Checked out with all motels and district personnel.
- f. Left West Yellowstone.
- g. Completion and operation of 24-hour radio service as warning system for residents of Ennis.
- h. SAFETY. Regional Safety Officer Fred Heinrich served as staff assistant to the Forest Service coordinator but found time to ride herd on the safety features of the job. Not a single lost-time accident was suffered by any Forest Service employee - even though the work pressures were great and the hazards high.

Aircraft pilots used caution and good judgment in attaining the large number of flying hours without mishap.

The Forest Service operation was closed as of this date without a single known injury.

SAFETY PAYS

B. SUMMARY OF ACTION - ENNIS-CLIFF AND WADE LAKES-MADISON RIVER SECTOR

1. August 18, 1:30 a.m. to 12:00 p.m. News of the disaster and reports of the possible failure of Hebgen Dam reached Ennis shortly after the earthquake.

Neil Howarth, Madison District Ranger, Forest Service, upon learning of the disaster undertook prompt action to expedite rescue operations. He called W. E. Fry of Dillon, Montana, Forest Supervisor, Beaverhead National Forest, and informed him of the disaster, giving the facts that he then knew. He also requested that an observation plane be sent to Dillon for his use at daybreak.

Initial reports covered at least two deaths which had occurred at Cliff Lake, and hinted at possible injuries of many other people camped in that area. By 3:30 a.m. the 600 people living in the town of Ennis, and 100 people living in lowland rural areas along the Madison River had been evacuated. The evacuation was made with the assistance of local, Federal, State, county, and municipal authorities, and with the invaluable aid of individual townspeople. Rumors that the dam had broken and that a wall of water was advancing down the Madison River spurred everyone in making a speedy evacuation. Some of the evacuees went to the homes of friends and relatives in nearby towns. A large number, however, established a camp on a bank above the town, where they were certain to be safe from threatening flood waters.

Blaine Tennis, Ennis District Ranger, Forest Service, and Neil Howarth, Madison District Ranger, jointly planned the radio communications needed in order to obtain needed information from disaster areas and to expedite action. They dispatched mobile and portable radio units to key areas.

Shortly after daybreak, Ranger Howarth made an observation flight over the disaster areas, reporting that the Hebgen Dam was holding satisfactorily, and that 75 to 100 people were stranded between the slide and the dam. He also reported 50 people stranded in the Cliff and Wade Lakes area. Upon Howarth's return to Ennis, he arranged to transport two nurses in his plane to an airstrip near Cliff and Wade Lakes to care for the injured in that area.

Shortly after, Harvey O. Robe, Assistant Regional Forester, arrived at Ennis, Montana, and established a base for search and rescue operations, placing Ernest Grambo, Forest Service, Missoula, in charge of all operations in the Ennis sector. At

the regional forester's request, Robe then went to West Yellowstone to organize Forest Service search and rescue operations in that area and to coordinate with Civil Defense units which were establishing headquarters there.

Additional Forest Service staffing arrived as ordered by air and car from the regional office in Missoula and adjacent national forests. This cadre of overhead (refer to Appendix 5) included people skilled in the various fields necessary to proper handling of an emergency situation. Dispatched with the first load of personnel were portable and more powerful radio sets and technicians to establish communications in the area and between Ennis and West Yellowstone.

The immediate objective was to coordinate the efforts of the various groups of local, Federal, State, county, and municipal groups. The efforts of these groups were organized and directed so as to obtain a maximum of accomplishment in search and rescue effort. Robert Frey and Jack Hamblet made a major contribution as staff assistants in effecting the needed coordination.

Frank Bailey, Assistant Forest Supervisor, Beaverhead National Forest, was assigned to head up rescue operations in the slide and Cliff Lake areas. A base camp was established just below the slide and District Ranger Chester Hagedorn was placed in charge of this unit. Another base camp was established in the vicinity of Cliff and Wade Lakes under the supervision of Robert Gibson, Lima District Ranger, and Henry Greitl, Forest Service. Sheriff Thomas of Beaverhead County and Sheriff Brooks of Madison County and their deputies contributed greatly to rescue operations in that area with the assistance of members of the State Highway Patrol.

Navy, Marine, and Air Corps reserve units arrived shortly before noon under the direction of Lt. Commander Carroll E. Davis. These units came from Butte and aided in operations at the slide area base camp and heliport and in the town of Ennis. The reserve units, accompanied by Dr. Coram, brought medical supplies, field kitchens, food and bedding. Major Robert L. Johnson and his crew of reserves contributed greatly to search operations, in addition to assisting in the care of evacuees from the town of Ennis.

Two bodies (refer to Appendix 6) were removed from the Cliff and Wade Lakes area by I. L. Todd, Montana State Game Warden, Dr. Losee, and County Coroner Charles Roper. Four bodies were removed to Ennis from below the slide area in the operations directed by Sheriff Brooks of Madison County and Frank Bailey, Forest Service.

About 30 people were evacuated from the Cliff and Wade Lakes area, transportation being provided by Coster and Johnson of the Bureau of Land Management, Earl Love, local SCS representative, and other cooperating individuals. A bulldozer was sent to the area by the Montana State Highway Department to do repair work on the road to permit removal of cars and trailers from the area.

Recordkeeping proved to be most important in order to keep pace with the fast-moving and complex operations and to maintain accurate records of people injured, evacuated, lost, etc. Dixie Brown, Art Johnson, W. E. Steuerwald, and Harry Gauld contributed in a major manner to this accomplishment.

The U. S. Forest Service continued its 24-hour radio standby to expedite the warning of people in Ennis in the event of actual failure of Hebgen Dam. This meant around-the-clock duty for all personnel of the Ennis and Madison Ranger Districts. Continued tremors felt in Ennis throughout the day and night did little to relieve the minds of the anxious people living in the area threatened by the flood waters.

Feeding and sleeping arrangements were provided in the high school for evacuees and were handled by the women of Ennis, with assistance of the military reserve units, Red Cross, and the generosity of local grocery store owners. Rangers Tennis and Howarth worked with local officials and Marshal George Hibert to set up a night patrol in the town to prevent the looting of abandoned homes. A youth CAP unit undertook the major burden of patrol duty. The Salvation Army of Bozeman sent a truckload of food and clothing which arrived in Ennis late in the evening for those people who had been hit by the disaster.

2. August 19. Ground and air search for additional victims or stranded people was continued with the assistance of many local volunteers below the slide along the Madison River and in the vicinity of Wade and Cliff Lakes.

A volunteer rescue team from Anaconda with skindiver equipment gave valuable assistance in searching the waters both below and above the slide.

Ranger Howarth, in cooperation with Mayor Bauer of Ennis, established a radio warning system to alert the local people in the event of failure of Hebgen Dam. After the arrangements had been made and warning signals printed and posted in town, the local people were advised by Mayor Bauer that they could, if they wished, return to their homes.

Don Nelson, Assistant Forest Supervisor, Beaverhead National Forest, directed the removal of cars, trailers, and personal belongings from Cliff and Wade Lakes immediately after the road was opened enough to make such action possible.

Aerial reconnaissance made on August 19 indicated several people stranded but not injured on the West Fork of the Madison River. A dozer was dispatched by the Montana State Highway Department to open the road on the afternoon of the 19th. Opening of the road was completed on the 20th and approximately 34 people were evacuated from the drainage.

State Representative Sumner Gerard, Deputy State Commander of the Civil Aeronautics Patrol, arrived to proffer the assistance of CAP in establishing vital radio communications between the Hebgen Dam and Ennis.

Rod Krout, assistant in charge of fire control for the State Forester, arrived to aid in the direction of search and rescue operations and to coordinate with the State Office of Civil Defense.

3. August 20. Efforts were continued to improve the communications system between Hebgen Dam area and the town of Ennis. An evacuation warning plan was developed for people in the rural areas. Search and rescue efforts were continued in the Madison River area and Cliff and Wade Lakes vicinity. Assistance was given by all units and individuals to aid the local Red Cross representative, Ralph Carlson, in collecting information regarding the victims and people stranded by the earthquake. Mr. Carlson performed a wonderful service for people affected by the earthquake.

A survey by air and ground was initiated by Beaverhead Engineer Bill Reeves to ascertain the extent of damage to the trails, roads, and numerous water-storage reservoirs in the Ennis and Madison areas. He was assisted by Venrick, Howarth, and Tennis.

Since the immediate emergency had been taken care of, steps were taken to reduce the strength of the Forest Service temporary emergency disaster organization, and continuing operations of a limited but essential nature were turned over to W. E. Fry, Forest Supervisor of the Beaverhead National Forest on August 21, 1959.

C. SUMMARY OF FOREST SERVICE EXPENDITURES

Salaries - 104 Forest Service employees	\$19,038
Per diem and travel	6,230
Johnson Flying Service - contract plane and pilot hire	25,400
Airplane rental - fire patrol contract (Beaverhead and Gallatin Forests) and charter planes	800
Vehicle use and transportation	16,200
Dozer use and transportation	3,200
Telephone - toll calls and instrument installation	2,800
Supplies and equipment - gasoline, oil, food and Forest Service warehouse issuances	1,800
Radio batteries, tubes, and repair	800
Installation and operation of radio warning service - Hebgen Dam to Ennis	840
Aerial photos, mosaics, maps - contributed to other agencies	1,750
Printing	900
Miscellaneous expense - office and headquarters rental, and miscellaneous costs	<u>2,000</u>
Total	\$81,758

PART III. EARTHQUAKE EFFECTS

A. FOREWORD

There are many things about the Hebgen Lake-Madison River earthquake which are difficult to explain. The statements made in this report represent our best judgment based on available information as of August 25, 1959. This information has been gleaned from on-the-ground observations, interviews with eyewitnesses, and numerous conferences and discussions with engineers and geologists of the U. S. Army Engineers, Geological Survey, Coast and Geodetic Survey, Montana Power Company, and many other agencies and private individuals.

B. FAULT LINES

The severe shock which took place at approximately 11:35 p.m., August 17, 1959, caused a sharply defined fracture in the earth's surface extending northwesterly from a point near the Yellowstone National Park boundary and passing just south of the junction of Highways U. S. 191 and Montana State Highway 287. It continues up the ridge east of Red Canyon Creek and thence northwesterly near the top of Kirkwood Ridge to Boat Mountain, approximately 2 miles north of the Hebgen Dam. Geologists consider this the line of an old fault. The fracture caused by the new quake showed a vertical displacement of 10 to 20 feet.

There was another lesser fault or break in the earth's surface extending from the major fault north of Armstrong on the Grayling arm of Hebgen Lake and thence northwesterly close to the lake along the north shore and past Hebgen Dam to the vicinity of Boat Mountain. These faults are shown on the map marked Appendix 1.

C. HEBGEN LAKE

The shock of the quake resulted in a subsidence of several feet in the area occupied by the middle portion of the lake. The old shoreline on both the north and south sides of the lake in the middle section are now several feet below water. In contrast, the Madison arm of Hebgen Lake apparently was uplifted. The old shoreline of this arm is now several feet above water. It appears that the area near Hebgen Dam itself remained relatively stable in regard to vertical displacement.

To illustrate what took place, the lake may be likened to a long, narrow, and shallow pan full of water. Assume that while one end of the pan remains at a constant level, it is bent in the middle so that the center section is depressed and the other end is raised above the original level. In this condition, the pan would overflow on both sides of the middle section.

This is apparently what happened at Hebgen Lake. The overflow at the middle section of the lake inundated roads and fences and undermined buildings. Willow bushes can be seen out in the lake more than 200 feet from present shorelines.

Geologists were not yet ready to make firm statements as to exactly what caused subsidence of the ground under Hebgen Lake. It does seem probable, however, that there might have been a combination of subsidence of the bedrock and a compression of the clay material which underlies the lake.

It also seems probable that some of the water in Hebgen Lake was literally squeezed through fissures in the earth to emerge in the form of muddy springs in numerous places throughout the area. Some of these eruptions of water brought up quantities of fine granular silt which flowed away from the fissure somewhat like a small flat volcano.

D. TIDAL WAVES

The uplift of the Madison arm of Hebgen Lake started a rush of water towards the dam. At the same time the settlement of the center portion of the lake would tend to cause a flow of water from the dam towards the center of the lake.

The net result of the earthquake action on the water in the lake was to create a series of tidal waves which overtopped the dam. There were three such surges of water, each followed by a subsidence of water at the dam to much below the normal level. After the waves quieted down, the gage at the dam indicated that the lake level was 0.74 feet lower than it was before the quake. This could indicate that the increase in reservoir capacity due to the subsidence of the center portion of the lake was somewhat greater than the loss in capacity due to the uplift of the Madison arm. On the other hand, an uplift of bedrock which supported the gage could give the same result.

Eyewitness accounts by employees of the Montana Power Company stationed at the dam indicate that the tidal waves overtopped the dam by 2 to 3 feet for the entire 700-foot length of the structure. In addition, there is ample evidence on the site to support the conclusion that the dam was overtopped for its entire length.

Eyewitness statements relate that the velocity of the tidal wave was such that it caused the water literally to leap over the top of the dam. This is supported by the fact that severe erosion on the face of the dam begins almost exactly along the break line between the roadway on the top of the dam and the sloping

downstream face. The roadway surface across the top of the dam showed little evidence of severe erosion. The water which overflowed the dam damaged the roof of a small power-generating plant and filled the power plant building with rocks and gravel to a depth of 2 to 4 feet.

E. HEBGEN DAM

Hebgen Dam is an earth-fill structure with a concrete core wall. It was constructed in 1913 with impervious selected material on the upstream side of the core wall and coarser material in the downstream portion of the dam. The core wall is supported on solid rock from the westerly end to a point approximately 45 feet from the spillway on the east end. For the remaining length of core wall and 65 feet of spillway, the structure is supported on the native clay foundation with a cutoff wall under the spillway. See following sketch of dam.

The earthquake caused several fractures in the core wall. Most of these showed no appreciable separation. At the point where the core wall was no longer supported on bedrock, the fracture separated 3 to 4 inches. Level readings by Montana Power Company engineers indicated that the two extreme ends of the core wall are still within .04 foot of being level. The section at the point of greatest fracture, however, is approximately 0.9 foot higher than either end of the core wall.

The spillway channel below the overflow section was quite severely shattered, as can be seen from photographs in the Appendix.

The sketch of the dam shows that the actual fill material of the dam is almost on bedrock near the west end of the structure and rests on deep natural clay formation for most of the easterly two-thirds of the length of the structure. The earth fill portion of the dam has settled in an amount varying from negligible on the west end to approximately 4 feet on the east end of the core wall near the spillway. The fact that this settlement increases almost directly in proportion to the increase in thickness of the natural clay under the fill supports the belief that the settlement of the dam may have been caused principally by compaction of the natural clay underlying the dam.

F. TIME RELATIONSHIPS

Physical evidence at the dam indicates that the surging tidal waves which overtopped the structure took place before the settlement of the earth fill material surrounding the core wall.

There is an earth and sod cover approximately 8 inches in depth over the top of the core wall. This cover matches the sod on the earth fill portion of the dam which has settled up to 4 feet. The

breakage line at the edge of the core wall is sharp. There can be little doubt that the tidal waves overtopped the dam before the earth fill portion of the dam subsided. Otherwise, this sod cover would have been washed off, or at the very least would have shown effects of overflow on the ragged earth edges. There is no such evidence.

Observations of the river channel below the big slide indicate that the river was at flood stage before the slide blocked the canyon. There is much evidence of water flow several feet higher than normal high water. The normal flow of the river would not provide enough water for such a big splash from the slide itself. This conclusion is further substantiated by the numerous fish found high and dry on the flat along the river bank several feet higher than the streambed. Most of the fish observed were the small catfish-like chubs. There were numerous trout and one 18-inch carp. (There is no place in the river below the pool at the toe of the dam where carp would likely be found.)

Evidence quite clearly indicates that the earthquake action which generated the tidal waves in Hebgen Lake did not cause instantaneous settlement of the earth dam or instantaneous release of the big slide.

The time elements involved in accelerating, decelerating, and reversing tidal waves in a large body of water such as Hebgen Lake would be considerable. All three tidal waves passed over the top of the dam before settlement of the earth fill took place. It can be assumed this was also before the rupture of the core wall and the shattering of the spillway channel.

At least the first surge of the tidal wave flood passed through the mouth of the canyon before the big rock slide occurred. It is possible the subsequent surges may have been caught behind the rock slide.

Considering the gradient and nature of the channel from Hebgen Dam to the mouth of the canyon, the surge of flood water would have required more than 30 minutes, and possibly 1 hour, to reach the slide area. It appears, therefore, that the settlement of the earth fill portion of the dam and the release of the big slide both took place more than $\frac{1}{2}$ hour after the initial tidal wave overtopped the dam.

G. THE BIG SLIDE

The bulk of the rock formation on the south side of the canyon, where the slide occurred, consisted of the stratified schist rock formation containing a considerable amount of mica. The layers of this formation lay parallel to the slope of the mountain. Due to the slippery mica and softness of the schist rock this was a highly unstable situation.

This rock mass was supported at the base by a dolomite or quartzite formation which extended diagonally across the base of the slide formation and disappeared into the canyon bottom. The area upstream from the slide had already been eroded to a stable angle of repose.

This formation consisted of a hard, brittle, quartzite-type of rock and acted as a sort of buttress to support the unstable schist mountainside above it.

The severe shock of the earthquake shattered this buttress which rendered it incapable of supporting the material above it. When the slide broke loose it pushed this dolomite or quartzite formation ahead of it and up the opposite side of the mountain to a height of almost 400 feet above the river bottom.

The photographs in the Appendix show that the timber covering the surface of the mountainside which slid out is now relatively uniformly distributed over the surface of the slide. This indicates little tumbling action of the slide. It seemed to simply slide down the mountain and up the other side with everything in its same relative position.

The crest of the slide at the point where water would overflow is approximately 150 feet above the river channel. It extends approximately $3/4$ of a mile along the river bottom.

The slide broke beyond the crest of the ridge on which it originated. The sharp edge where the slide broke the top of the ridge is at approximate elevation of 7,500 feet above sea level. This is about 1,200 feet above the bottom of the canyon. See the following contour map and the photographs in Appendix for more details concerning the shape and makeup of the slide and slide area.

Preliminary elevations made by a helicopter altimeter indicated the crest of the slide to be at approximately elevation 6,460. Latest reports from Army Engineers place the overflow crest at 6,464. The base of the Hebgen Dam is roughly 6,460. This means when the lake behind the slide is full, water will back up to the toe of Hebgen Dam.

The U. S. Army Engineers reported as follows:

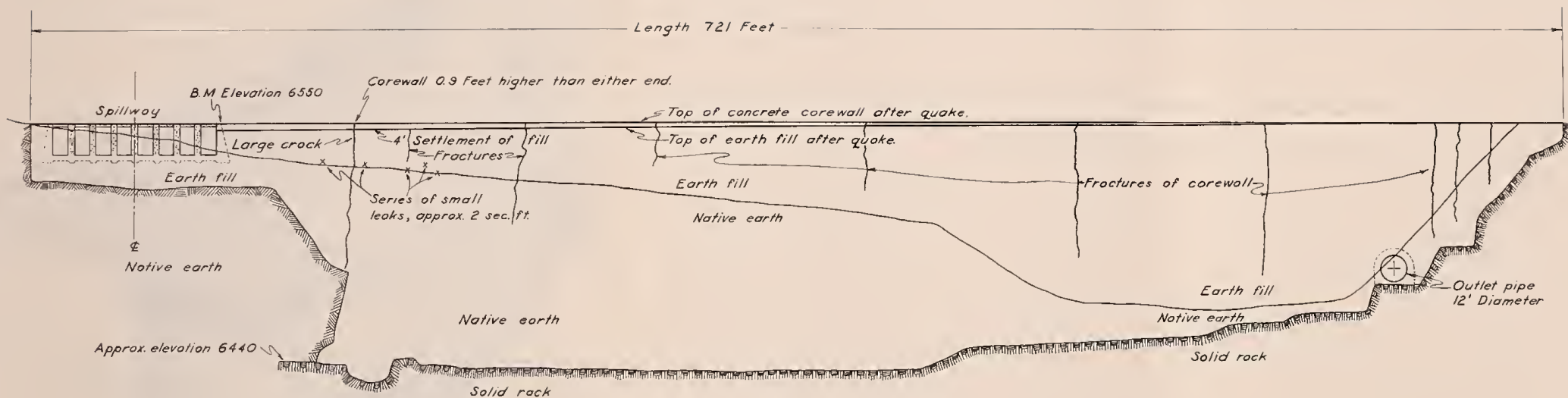
1. The slide itself is safe. There is no danger of it being washed out by the water impounded behind it.
2. There is an impervious blanket of material on the upstream face of the slide. This points to a minimum of seepage through the mass of the slide.

3. While their line of levels had not been completely checked, preliminary indications were that if water should rise to the crest of the slide, it would come very near to the toe of the Hebgen Dam.

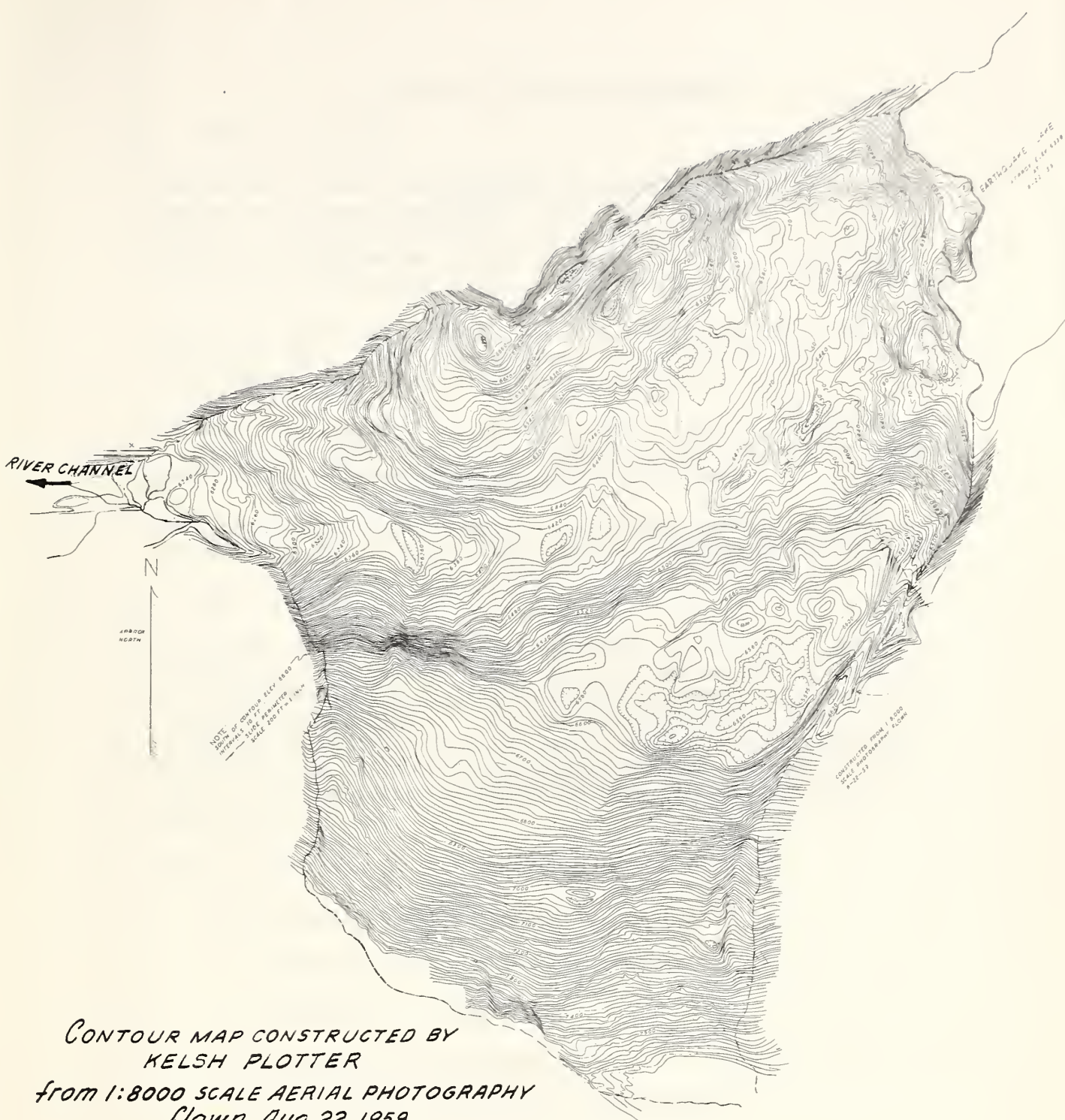
H. WORK ON SLIDE

The Army Engineers are engaged in constructing a rough road to the crest of the slide. The plan is to cut the crest down about 14 feet to prevent saturating the toe of the Hebgen Dam. This will provide a relatively smooth overflow channel.

The Army Engineers also plan to place movement points on the slide to detect future movement. They may put in piezometer wells to check water levels in the slide and may also make borings to determine the composition of the slide.

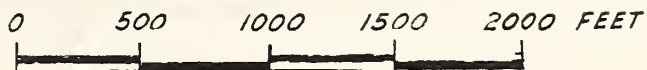


SKETCH OF
CROSS SECTION OF HEBGEN DAM ON CENTER LINE OF COREWALL
LOOKING UPSTREAM



CONTOUR MAP CONSTRUCTED BY
KELSH PLOTTER
from 1:8000 SCALE AERIAL PHOTOGRAPHY
flown Aug. 22, 1959
by U.S. FOREST SERVICE

EARTHQUAKE SLIDE MADISON RIVER-1959



PART IV. APPRAISAL OF DAMAGES

A. METHOD OF SURVEY

A systematic survey and appraisal of damage from the quake was started on Thursday, August 20, 1959. The damage survey and appraisal operation consisted of four phases. The first was collection and compilation of miscellaneous bits of information picked up in the course of the regular search and rescue operation.

The second phase was an intensive area search carried on by means of helicopters. This phase was handled concurrently with the final aerial search for persons injured or in distress.

The third phase of the damage survey was to make on-the-ground examination of special situations where damage appeared the heaviest or where additional checking seemed necessary.

The fourth phase was to compile, study, and evaluate the data collected in the course of the first three phases of the operation.

B. AREA COVERED

In carrying on the second phase, the area to be covered was divided into four parts. These are shown on the map in Appendix 1. There were four U. S. Air Force helicopters available for this search and rescue mission. One was assigned to each area. A Forest Service officer familiar with the area acted as observer. His mission was to look for persons in need of assistance and to record data on evidence of damage to physical improvements or watersheds.

Instructions given to each observer were as follows:

1. Record data on observed damage to:
 - a. Forest development roads and trails.
 - b. Forest Service campgrounds.
 - c. Forest Service buildings.
 - d. Forest Service miscellaneous improvements.
 - e. State or county roads.
 - f. State or county miscellaneous improvements.
 - g. Summer homes on national forest.
 - h. Other private property on national forests.

2. Indicate nature and extent of watershed damage. Show on map locations of slides, faults, and other disturbances.
3. Report approximate length of damaged roads and trails in miles and tenths of miles. Note whether damage is light, medium, or severe.
4. Do not estimate cost of damage repair. Try to describe it.
5. Report on any damage within your area that may be of concern to the State or a Federal agency.
6. Stop to investigate fully when necessary to get a good appraisal of damage to national forest property.
7. Do not include Hebgen Dam, the big slide, or damage to fisheries below big slide. This will be covered separately.

C. SUMMARY OF ESTIMATED RESTORATION COSTS

The results of the evaluation and appraisal of damage are shown in the following tabulations:

NATIONAL FOREST EARTHQUAKE DAMAGE SURVEY

Summary of Estimated Restoration Costs

Forest highways	31.2 miles	\$4,200,000
Forest development roads	52.1	350,000
Trails	34.0	43,120
Campgrounds	83 family units	139,440
Structures and facilities	10 each	29,330
Other improvements	-	29,400
Fish and wildlife habitat damage repair	3,800 feet	53,000
	1,325 acres	37,000
Watershed restoration	-	55,000
Removal of slide rock on slopes to correct dangerous conditions created by quake	- lump sum	84,000
Cleanup of debris in lake and removal of inundated timber	200 acres	<u>100,000</u>

<u>Damage to roads</u>	<u>Number of miles</u>	<u>Estimated restoration cost</u>
<u>Forest highways</u>		
Gallatin #45	29.1	\$4,000,000
Gallatin #42	<u>2.0</u>	<u>200,000</u>
Subtotal	31.2	\$4,200,000
<u>Forest development roads</u>		
Gallatin		
Cabin Creek #986A	0.5	9,800
Cabin Creek #986	0.2	3,920
Red Canyon Creek #681	2.5	1,400
Beaver Creek #985	4.0	16,800
Hebgen Lake #167	11.0	115,500
South Fork Madison #478	4.0	1,400
Horse Butte #610	2.5	7,000
Horse Butte Lookout #610B	1.8	1,260
Ski Hill #1034	2.3	1,610
Trappers Creek #1756	4.0	2,800
Miscellaneous campground roads	10.0	158,200
Beaverhead		
Wade Lake #572	0.5	21,000
Cliff Lake #5782	1.5	4,200
West Fork Madison #209	7.0	4,900
Neeley's Camp #641	<u>0.3</u>	<u>840</u>
Subtotal	52.1	350,000
Total	83.3	\$4,550,000

<u>Damage to trails</u>	<u>Number of miles</u>	<u>Estimated restoration cost</u>
Gallatin		
Cabin Creek #207	1.5	\$4,200
Upper Tepee #208	1.5	4,200
Little Tepee #209	1.5	4,200
Kirkwood Cabin #210	1.5	4,200
West Fork Beaver #222	1.5	4,200
Beaverhead		
Standard #23	.2	560
Cliff Lake Bench #20	.5	2,800
Hidden Lake #35	.3	420
Papoose Creek #355	3.0	12,600
Deerlodge		
Rock Creek #53	7.0	1,960
Hi Line #111.3	10.0	2,100
Louise Lake #150	2.0	700
Curley Creek #151	<u>3.5</u>	<u>980</u>
Total	34.0	\$43,120

<u>Damage to campgrounds</u>	<u>Number of family units</u>	
Beaverhead		
Wade Lake Camp	6	\$10,080
Cliff Lake	2	3,360
Cliff Point	4	6,720
Gallatin		
Madison	15	25,200
Rock Creek	40	67,200
Upper Cabin	4	6,720
Lower Cabin	5	8,400
Spruce Lane	5	8,400
Cherry Camp	<u>2</u>	<u>3,360</u>
Total	83	\$139,440

<u>Damage to structures and facilities</u>		<u>Estimated restoration cost</u>
Gallatin		
Basin Station	Lump sum	\$3,500
Cinnamon Lookout	Lump sum	1,400
Horse Butte Lookout	Lump sum	700
Miscellaneous damage to water and sanitary system		3,500
Beaverhead		
Crockett Lake Cabin	Lump sum	700
Black Butte Cabin	Lump sum	280
West Fork Cabin	Lump sum	1,400
Landon Cabin	Lump sum	1,400
Wall Creek Station	Lump sum	2,800
Miscellaneous damage to water and sanitary system		3,500
Deerlodge		
Thunderbolt Lookout	Lump sum	350
Emerine Lookout	Lump sum	<u>9,800</u>
Total		\$29,330

Damage to other improvements

Beaverhead		
Re-establish water development range	10 each	\$8,400
Change fences due to water development changes	15 miles	<u>21,000</u>
Total		\$29,400

Privately Owned Improvements on Forest Service Land

<u>Kind of improvement</u>	<u>Location</u>	<u>Kind of damage</u>	<u>Number</u>
Beaverhead - summer homes	Wade and Cliff Lakes	Moderate to heavy damage	3
Gallatin - summer homes	Madison slide area and Hebgen Lake	Light, medium and heavy damage	85
Beaverhead - Wade Lake Resort	Wade Lake	Heavy	1
Gallatin - resorts Campfire Inn	Slide area	Destroyed 14 cabins, store, and residence	1
Halford's Camp	Slide area	Destroyed	1
Thornton Lodge	Slide area	Destroyed	1
Miller's	Slide area	Destroyed	1
Range improvements			
Beardsley - pipeline	Cliff Lake	200 feet pipeline destroyed	
Robison - pipeline, pump and pumphouse	Hidden Lake	1,300 feet pipe, pump and pumphouse	

D. EARTHQUAKE DAMAGE TO HABITAT FOR FISH AND GAME

1. Fishery Habitat. Fish habitat in the earthquake area on the West Yellowstone District of the Gallatin was checked by helicopter and by airplane on August 24 and 25, 1959. Observations made must be considered as only preliminary. It is assumed that the Montana Fish & Game Department and the Bureau of Sport Fisheries and Wildlife will make surveys to assess damages more accurately. Beyond any doubt there have been serious impacts on fisheries habitat. The exact extent of these damages cannot be determined until all the effects of the earthquake have been evaluated. Moreover, mudflows in springs and changes in aquifers are still continuing.

- a. The New Lake. A comprehensive study of the Madison River Fishery made by the Bureau of Sport Fisheries and Wildlife, 1950 to 1952, is available for use in evaluating damage. That study indicated that on the basis of fishermen expenditures, a mile of the Madison River Canyon had an annual fisheries value of \$5,837.60. When adjusted to 1958 on the basis of Forest Service recreation statistics, this value is \$7,612.56 per mile of stream. The big slide which created the new lake eliminated 3/4 of a mile of the Madison River Canyon forever. The annual value of this loss, based on 1958 statistics, is \$5,679.42.

Seven miles of the Madison River Canyon will be flooded. The value of the lake which will replace the stream will be difficult to assess until the lake has been established and recreation use has started. However, it is reasonable to believe that the new lake fishery will not be as valuable as the original river fishery for these reasons:

- (1) The new lake will be a long, narrow, deep body of water, with little productive shoal area as compared to Hebgen Lake immediately upstream. Replacement of water in the new lake may be rapid because of the large inflow which averages 2,000 c.f.s. during the summer months and up to 2,700 c.f.s. during the fall. This could produce rapid dilution of basic plant nutrients and plankton in the lake and thus result in low productivity.
- (2) The Bureau of Sport Fisheries and Wildlife study referred to previously indicated that the catch per man-hour on Hebgen Reservoir was one-third less than in the Madison River Canyon. It is our

opinion that the new lake will be less productive than Hebgen Lake. Thus, the new lake would appear to be a potentially less valuable fishery than the original Madison River Canyon.

- (3) Angling in the new lake will be difficult because of the great quantity of submerged timber. Access to the new lake will be difficult as compared to the original stream. The new lake will be less attractive to fishermen because of greatly reduced esthetic values.

There is a possibility that the water will become warmer than that in Hebgen Lake because of the additional impounding. This could have a serious impact on the Madison River fishery below the big slide because temperatures approaching the critical point for trout have previously been recorded below Hebgen Dam. However, if density currents are formed, cooler water might be carried along the bottom of the lake to the overflow on the slide. Should this happen, cool water would pass into the river below the slide.

Loose earth in the slide may cause sedimentation in the river downstream. The principal damage would be to stream productivity. Probably within a year or so silt damage would be lessened because of the swift nature of the Madison River. Even so, the end result would be additional harmful sedimentation in the Ennis Reservoir.

- b. Hebgen Lake. Reduced productivity in Hebgen Lake could result from sedimentation and consequent increased turbidity. Several sources of sediment are apparent.

Slides and faults along the north shore of the lake have exposed bare soil to wave action. On August 25, moderate winds had caused rather severe turbidity as much as 100 feet from the shoreline. It is possible to prevent this damage by the installation of sheet piling and bank stabilization of the exposed raw slopes. It is estimated that 3,800 linear feet of shoreline will require treatment at a cost of \$53,000 to eliminate this source of sedimentation.

Mudflats exposed by the earthquake along the south shore of the lake at the upper end are another source of sediment during periods of high wind. These too can cause increased turbidity. This source of sediment could be partially eliminated by seeding these exposed areas. It is estimated that 1,325 acres should be reseeded at a cost of \$37,000.

A third source of sediment is mudflow from springs on the bottom of the lake. It is not known how extensive this is, but at least one mudflow was observed along the north shoreline.

Sedimentation in the lake from Grayling, Duck, and Cougar Creeks, and the South Fork of the Madison River is serious. When observed on August 24, these streams were producing large quantities of fine, brown silt. How long this condition will continue is not known. Several geologists expressed the opinion that it would probably abate within a few weeks to several months. There does not appear to be any way to eliminate this source of sedimentation.

- c. The Streams Above Hebgen Lake. Most of the streams entering Hebgen Lake are turbid. In nearly all cases this is caused by mudflows from springs. Mudflows in Grayling, Duck, and Cougar Creeks, and the South Fork of the Madison River are sufficient to seriously impair trout stream habitat. The extent of this damage will depend on the length of time that the mudflows continue. However, there is no doubt that spawning facilities and food production will be damaged.
2. Game Habitat. The only apparent loss of game habitat will be that due to flooding by the new lake. It appears that approximately 500 acres of mule deer winter range will be inundated. The dollar value of this game range cannot be estimated.

It is not practical to attempt to replace this lost range somewhere else. The loss of this key winter range area will of necessity be reflected in the future management of the deer herd by the Montana Fish & Game Department. Such management will probably indicate the need for maintaining a smaller deer herd and thus a smaller game harvest for hunters.

PART V. CASUALTIES

Based on the most reliable information available as of 6:00 p.m. August 26, 1959, there are nine known dead. (Refer to Appendix 6.)

Twenty-five persons were hospitalized for treatment of serious injuries at Bozeman, Ennis, Butte, and Sheridan, Montana.

In addition to those hospitalized, numerous individuals were given first aid for minor injuries. The American Red Cross, doctors, nurses, Forest Service smokejumpers, Armed Service units, and many others performed admirably in caring for the injured.

As of 6:00 p.m., August 26, a total of 53 persons who were presumably within the disaster area at the time of the earthquake have not been located.

PART VI. CONGRESSIONAL DAMAGE SURVEY PARTY

At 6:00 a.m. (on Saturday, August 22) a Congressional delegation left Washington, D. C., by plane en route to the disaster area for firsthand observation of the damage and problems involved. The trip was arranged at the request of Senator James E. Murray (D-Mont.), Senate Interior and Insular Affairs Committee chairman. The group was headed by Senator Frank E. Moss (D-Utah), member, Senate Interior and Insular Affairs Committee and Senate Public Works Committee, and Representative Lee Metcalf (D-Mont., Western District), member of the House Ways and Means Committee.

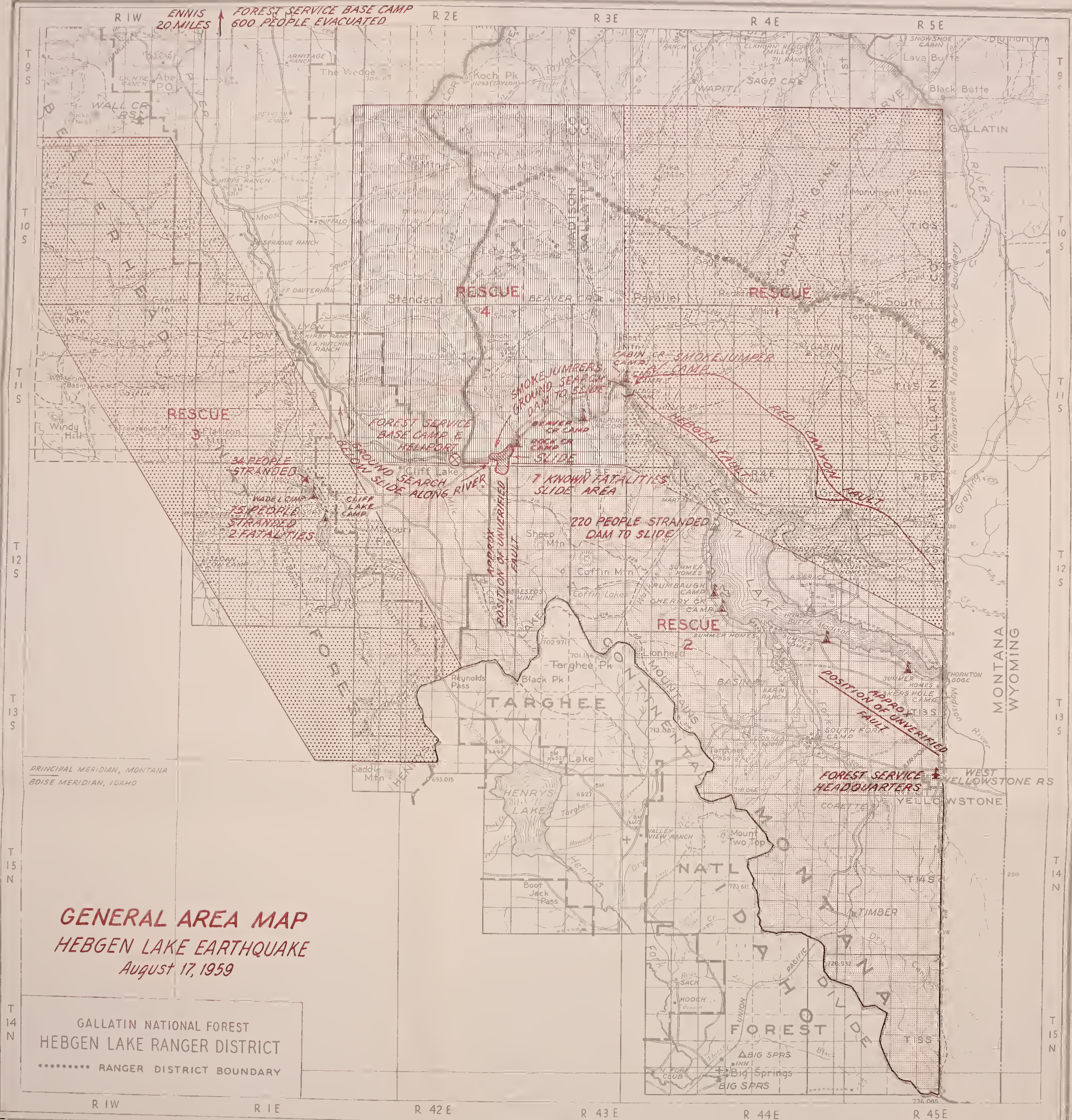
Administrative and staff assistants to Congressmen, and representatives of Federal agencies, including Assistant Chief E. P. Cliff and Clint Davis, U. S. Forest Service, Washington, D. C., accompanied the Congressional party. Refer to Appendix 7 for list of names.

The delegation was met at Bozeman, Montana, by Governor J. Hugo Aronson, Associate Justice Wesley Castles, State Highway Engineer Fred Quinell, State Highway Commissioner L. V. Swanson, Yellowstone Park Superintendent Lon Garrison, and Regional Forester Charles Tebbe, Assistant Regional Forester Ed Barry, Forest Supervisor W. E. Fry, Beaverhead National Forest, Forest Supervisor George Duvendack of the Gallatin National Forest, and others. This group accompanied the delegation to West Yellowstone.

Transportation to West Yellowstone was by air, and this proved valuable for early orientation as the trip was designed to show the relationship between the town of Ennis, slide area, and the Hebgen Dam. Aerial photographs and maps showing key areas, preliminary disaster action reports, and other informative material was furnished to each member of the party by Regional Forester Tebbe.

Upon arrival at West Yellowstone, members of the delegation toured the disaster area in Air Force helicopters. After all members had inspected the disaster area, a briefing session was held at the Stagecoach Inn at 7:30 a.m. Hugh Potter, State Director of Civil Defense, opened the meeting and explained early action taken by his office. Gareth C. Moon, Montana State Forester and Director-Deputy of Civilian Defense, and H. O. Robe, Coordinator, U. S. Forest Service, summarized search and rescue operations and damage survey action taken in the disaster area.

On August 23 at 8:00 a.m. the Washington delegation left West Yellowstone. The group returned to Bozeman by automobile in order to further inspect and check on road damage and then returned to Washington, D. C., by plane.



MAP OF EARTHQUAKE LAKE

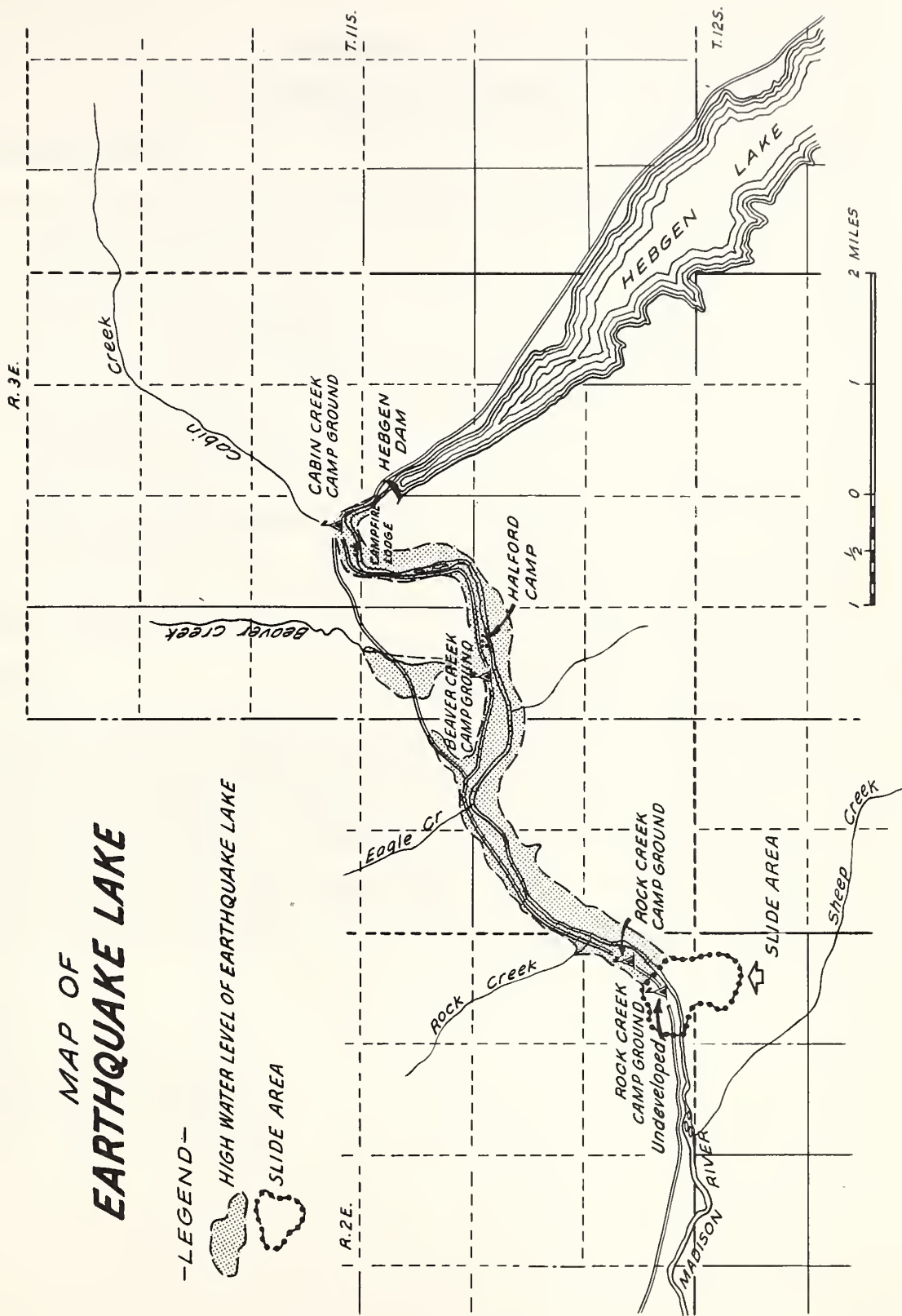
-LEGEND-



HIGH WATER LEVEL OF EARTHQUAKE LAKE



SLIDE AREA



Appendix 3

LIST OF COOPERATING ORGANIZATIONS

FEDERAL AGENCIES

Office of Civilian Defense Mobilization, Region 8
U. S. Forest Service
 (Johnson Flying Service)
U. S. Park Service
U. S. Bureau of Reclamation
U. S. Army Corps of Engineers
U. S. Bureau of Public Roads
 (Naranche & Konda construction contractors)
U. S. Geological Survey
U. S. Fourth Air Force
 Hamilton AFB - California
 Hill AFB - Utah
 Malmstrom AFB - Montana
 Stead AFB - Nevada
U. S. Marine - Navy - Air Force Reserve (Butte)

STATE AGENCIES

Montana

Montana Governor's Office
Montana Director of Civil Defense
Montana State Highway Patrol
Montana State Highway Department
Montana State Forestry Department
Montana State College
Montana State Fish & Game Department
Montana Aeronautics Commission
Montana Civil Air Patrol

Idaho

Idaho State Police
Idaho National Guard
Idaho Civil Defense
Idaho Highway Department

OTHER AGENCIES AND INDIVIDUALS

American Red Cross
Salvation Army
Sheriff, Gallatin County
Sheriff, Madison County
Mayor and Town Council of Ennis
Montana Power Company
Anaconda Rescue Unit, Deer Lodge
Livingston and Bozeman Rescue Units
Bozeman Sheriff's Posse
West Yellowstone Lady Lions
West Yellowstone Chamber of Commerce
Warm River Lumber Company
Doctors and nurses - Ennis, West Yellowstone, and from
 within disaster area
And many other cooperating organizations and individuals

Appendix 4

LIST OF PEOPLE WHO ATTENDED AUGUST 18
COORDINATION MEETING AT
WEST YELLOWSTONE RANGER STATION

<u>Name</u>	<u>Agency</u>	<u>Address</u>
Charles A. Lynch	Aeronautics Commission	Billings (Helena)
Col. G. B. Bennett	Idaho National Guard	Boise
Cliff Amundsen	BLM	Shoshone, Idaho
Lt. Ervin T. Dunn	Idaho State Police	Idaho Falls
Capt. Ben T. Neuman	Idaho State Police	Rexburg
Lt. Earl A. May	Hill AFB, Rescue	Layton, Utah
Mark Radcliffe	Mont. Aeronautics Commission	Helena
Maj. George H. Carlton	Mont. State College AFROTC	Bozeman
Lt. Col. Richard E. Oliver	Idaho National Guard	Idaho Falls
Jim Manion	U. S. Park Service	West Yellowstone
Joe Fraser	U. S. Park Service	West Yellowstone
Capt. Andrew S. Champion	U. S. Air Force	Hamilton AFB, Calif.
Lt. James W. McElhaney	U. S. Air Force	Malmstrom AFB, Mont.
Lt. Zane L. Lantz	U. S. Air Force	Hill AFB, Utah
Capt. Walter F. Huber	Idaho National Guard	Boise
Supt. Alex B. Stephenson	Montana Highway Patrol	Helena
A. E. Zion	Montana Highway Department	Helena
Swede Lindgren	Montana Highway Department	Helena
Lewis Ross	Idaho Civil Defense	
Howard Wakley	Special Agent, U. P. R. R.	
Harvey O. Robe	Disaster Coordinator, U. S. F. S.	Missoula
George Duvendack	Forest Supervisor, Gallatin	Bozeman
Craig Silvernale	District Ranger, Gallatin	West Yellowstone
Fred Heinrich	Safety Officer, U. S. F. S.	Missoula
John Milodragovich	Division of State and Private, U. S. F. S.	Missoula
Ed Barry	Division of Recreation and Lands, U. S. F. S.	Missoula

Appendix 5

FOREST SERVICE PERSONNEL PARTICIPATING IN
SEARCH, RESCUE, AND DAMAGE SURVEY OPERATIONS

Beaverhead National Forest

<u>Name</u>	<u>Title</u>	<u>Address</u>
W. E. Fry	Forest Supervisor	Dillon
Elaine Tennis	District Ranger, Ennis District	Ennis
Neil J. Howarth	District Ranger, Madison District	"
Dixie Brown	Ranger Clerk	"
Henry Greitl	Alternate Ranger, Madison District	"
Richard DeVries	Grazing Guard, Madison District	"
Bernard Jones	Laborer, Madison District	"
Tom Jones	Headquarters Guard, Madison District	"
Rodger Kent	Laborer, Madison District	"
Charles Edgmond	Strawboss, Madison District	"
Frank Bailey	Asst. Supervisor	Dillon
Chester Hagedorn	District Ranger, Dillon District	"
H. B. Rogers	Forest Dispatcher	"
Donald Whipple	Administrative Asst.	"
Robert Brandenberger	Forest Staff	"
Robert Gibson	District Ranger, Lima District	Lima
James Fishburn	Asst. Ranger, Wise River District	Wise River
Donald Nelson	Asst. Supervisor	Dillon
John Venrick	District Ranger, Sheridan District	Sheridan
Don Jenni	Alternate Ranger, Ennis District	Ennis
Bill Reeves	Forest Engineer	Dillon
Blaine Doyel	Administrative Officer	"
Ross Greenfield	Communication Technician	"
Lee Spohlver	Headquarters Guard, Sheridan District	Sheridan
Rod Hancock	Engineering Aid	Dillon

Gallatin National Forest

Geo. H. Duvendack	Forest Supervisor	Bozeman
D. W. Beaman	Asst. Supervisor	"
H. F. Johnson	Forest Engineer	"
Roy E. Berg	Administrative Asst.	"
Elton Elliott	Forest Dispatcher	"
Craig W. Silvernale	District Ranger	West Yellowstone
Gary P. Wetzsteon	Asst. Ranger	" "
Harold L. Brown	Timber Management Asst.	" "
Donald J. Heath	Headquarters Guard	" "
Guy E. Hanson	Prevention Guard	" "
Richard Aho	Horse Butte Lookout	" "
Richard W. Drew	Laborer	" "
Alvin R. Briggs	Laborer	" "
Elmer C. Amundson	Laborer	" "
William N. Miller	Laborer	" "

Gallatin National Forest (continued)

<u>Name</u>	<u>Title</u>	<u>Address</u>
James H. Henkel	Laborer	West Yellowstone
Dick Joy	Asst. Ranger, Squaw Creek District	Gallatin Gateway
Furman Wolf	ACODR, Administration Buildings	Ennis
Tom Comstock	Lookout, Lookout Mountain	Gardiner
Duane Meyers	Dispatcher	"
Carl Marsh	District Ranger	"
Orville Hart	Survey Crew	Bozeman
George Olson	Survey Crew	"
Larry Walker	Survey Crew	"
Jack Jones	Range Aid	"
Larry Jack	Communications Technician	"

Regional Office Personnel - Missoula, Montana

Smokejumpers

Al Hammond, in charge of parachute rescue	Pat Schied, jumper
Bob Nicol, squad leader	Lowell Hanson, jumper
Jim Burleigh, jumper	Joe Roemer, jumper squad leader
Dick Tracy, jumper foreman	Vance Warren, jumper squad leader
Roland Andersen, jumper foreman	Nils Troetsson, jumper
John R. McLaughlin, jumper	Randle Hurst, jumper squad leader

Chas. L. Tebbe	Robert E. Frey	Arthur A. Johnson
Harvey O. Robe	C. B. Wescott	Stewart Hughes
John Milodragovich	W. E. Steuervald	Ross Angle
Fred Heinrich	Fred Brauer	Clarence Sharp
Ed Barry	Andrew R. Fink	Burt Anderson
A. L. Anderson	Harry Gauld	Bernard H. Glaus
R. M. (Max) Peterson	John F. Hamblet	George Christensen
C. B. Sutliff	Inez Jarvis	Fred Fite
Jack Nash	Nora Regenos	David Kyle
Dale Thornburg	Drucie Otterson	W. R. Moore
Ernie Grambo	John H. Coats	Homer J. Hartman

Johnson Flying Service Pilots
(Under contract with U. S. Forest Service)

<u>Helicopters</u>	<u>DC-3's</u>	<u>Twin Beech</u> (photography)
Fred Gerlach	Ken Roth	Bill Ladwig
Rod Snyder	Swede Nelson	
	Bob Schellinger	
<u>DC-2's</u>	Mark Starr	
Mel Callaway		

Appendix 6

KNOWN FATALITIES AS OF AUGUST 22, 1959

<u>Name</u>	<u>Address</u>
Mrs. Margaret Holmes	Unknown
Purley Bennett) Tommy Bennett) Carole Bennett) Susan Bennett)	Coeur d'Alene, Idaho
Mr. E. H. Stryker) Mrs. E. H. Stryker)	San Mateo, California
Mr. Thomas M. Stowe	Sandy City, Utah
Mrs. Myrtle Painter	Ogden, Utah (died in hospital, August 20, 1959)

Appendix 7

MEMBERS OF CONGRESSIONAL PARTY

1. Senator Frank E. Moss (D-Utah), member Senate Interior and Insular Affairs Committee and Senate Public Works Committee.
2. Representative Lee Metcalf (D-Mont., Western District), member House Ways and Means Committee.
3. Representative LeRoy Anderson (D-Mont., Eastern District), member House Interior and Insular Affairs Committee.
4. Gracie Pfost (D-Idaho), Chairman House Interior and Insular Affairs Subcommittee on Public Lands, and member House Public Works Committee.
5. Representative John Baldwin (R-Calif.), House Public Works Committee.
6. Representative Harold Johnson (D-Calif.), House Public Works Committee.
7. Representative Thomas G. Morris, House Interior and Insular Affairs Committee.
8. Joe Brennan, Engineer Consultant, House Public Works Committee.
9. John Carver, Administrative Assistant to Senator Church (D-Idaho).
10. E. P. Cliff, Assistant Chief, U. S. Forest Service.
11. Clint Davis, Director, Division of Information & Education U. S. Forest Service.
12. Mike Deevy, assistant to Representative LeRoy Anderson.
13. Eugene Eaton, Engineer, Senate Interior Committee.
14. Dr. Raymond Johnson, chief of Division of Sport Fisheries and Wildlife, U. S. Fish & Wildlife Service.
15. Mike Menatos, Administrative Assistant to Senator Joseph O'Mahoney (D-Wyo.), chairman of Senate Interior and Insular Affairs Public Lands Subcommittee.
16. Major Robert Meade, Air Force Escort.
17. Col. Oren Olmstead, acting chief of civil works, Army Corps of Engineers.

18. Vic Reinemer, Executive Secretary to Chairman Murray (D-Mont.) of Senate Interior and Insular Affairs Committee.
19. Earl C. Reynolds, Administrative Aide to Senator Henry Dworshak (R-Idaho), ranking minority member, Senate Interior and Insular Affairs Committee.
20. E. T. Scoyen, Associate Director, National Park Service.
21. Robert Wolf, Forester, Senate Interior and Insular Affairs Committee.



Madison Canyon before slide.



Madison Canyon after slide.



Slide Origin

West side of Madison River - view from high point of
slide debris.



Massive Rock Slide

Downstream face of rock slide. State Highway 1 and
dry Madison River channel in foreground.



Photograph Courtesy of Montana State Highway Department

Fault Along South Slope of Kirkwood Ridge

This roughly parallels the north shore of Hebgen Lake.



Fault line near top of Kirkwood Ridge east of Hebgen Lake. Vertical displacement along this fault is as great as 21 feet.



Hebgen Fault

A portion of the Hebgen fault north of Hebgen Lake. Notice where State Highway and building slipped into lake. Road between fault and slip out was built to evacuate trapped people.



Earthquake Lake

Lower end of lake at upstream edge of slide. Lake beginning to fill. Flooded tree area in center of picture is Rock Creek Campground.



Earthquake Lake

Upstream view on August 21, 1959, of lake gradually filling and flooding highway, campgrounds, and resorts.



Earthquake Lake being formed behind slide in Madison Canyon. Note submerged trees lining old river channel.



Earthquake Lake

Lake at upper face of slide. Flooded trees in center of picture indicate location of Rock Creek Campground.



Madison River Below Slide

River almost dry below slide. Note high water marks and debris left by tidal wave from Hebgen Lake.



Hebgen Lake Dam

Note damaged spillway and erosion on face of dam due to tidal wave overflow. Hebgen fault line in left edge of picture.



Hebgen Dam being repaired following earthquake of August 17, 1959. This dam is earth-fill with concrete core. Note how earth settled below concrete core.



Cliff Lake Campground

Note camp table with food, smashed car, and large boulders on top of tent.



Wade Lake

Part of forest road taken out by slide.



21-foot vertical displacement in Red Canyon near Hebgen Lake.



Highway Leading to Madison River Canyon

Road is at base of mountains in Madison Mountain Range.



Collapsed culvert drainage structure on road at Culligan Ranch near Hebgen Lake.



Roof of barn at Culligan Ranch, lying on ground.



Damaged building on shore of Hebgen Lake. Note three sections of chimney.



Forest Service radio point at Hebgen Dam for communications with West Yellowstone and Ennis. Equipment on dam is making repairs.



Smokejumper

Forest Service smokejumpers descended between the slide and Hebgen Dam to administer first aid and assist trapped campers.



Water is beginning to flow over the crest of and down the front face of the earthquake slide through the spillway prepared by the Corps of Engineers. Time: Approximately 10:00 a.m., September 10, 1959.

Q



Water flowing from Earthquake Lake through spillway into Madison River. Time: 1:03 p.m., September 10, 1959. Flow of Madison River had been cut off by the slide since August 17, 1959. Note braided flow pattern in lower part of spillway and Madison River in lower center of picture. Vehicles are parked on Montana State Highway 287 and construction roads on the slide.



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